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Three new species of Genus *Cryptonatica* (Gastropoda, Naticidae) from Huanghai Sea Cold Water Mass

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Abstract
This report based on the results of investigations conducted in June 2007 and July 2008, respectively, on the benthic community structure and characteristic diversity of the Huanghai Sea (Yellow Sea) Cold Water Mass, as well as that in July 1959 during the national oceanic survey. The Naticidae specimens collected from Cold Water Mass in middle and northern Huanghai Sea were studied through morphological classification and the internal anatomy on radula. Three new species of Naticidae, i.e., *Cryptonatica purpurfunda* sp. nov., *Cryptonatica sphaera* sp. nov., and *Cryptonatica striatica* sp. nov. were identified. The morphological characteristics of the new species are described, and the similarties and differences between the new species and similar species are compared and discussed.

Key words: Mollusca, Gastropoda, Naticidae, *Cryptonatica*, new species, Huanghai Sea Cold Water Mass

1 Introduction

The Naticidae are worldwide distributed species, from cold to tropical waters, while some of them are only distributed in cold and temperate waters. The Huanghai Sea, as a semi-enclosed shallow sea, located between the northern China Mainland and the Korean Peninsula, only connected to the East China Sea in the south. The average water depth of the Huanghai Sea is 44 m, and due to the unique environment, the Cold Water Mass was formed in Huanghai Sea. Even the surface water temperature reached 25 °C in summer, however, due to the lack of adequate exchange, the bottom water is still maintained at a temperature as low as only 6–8 °C. Generally, the temperature of Huanghai Sea Cold Water Mass keeps at a range of 5–11 °C year round. This is the most prominent hydrological characteristic of the Huanghai Sea. As a result of this special geographical hydrological environment, there is a number of cold-temperate water species from the North Pacific Ocean inhabit here. Golikov and Sirenko (1988) recorded, some Naticidae species are only distributed in cold and temperate waters. For example, genus *Cryptonatica* Dall 1892 is distributed mainly in cold and temperate waters of the northern Hemisphere. Its species settle, for the most part, on sandy or muddy-sand substrates from the lower horizon of the littoral zone down to the bathyal zone. While *Cyptonatica andoi* (Nomura, 1935), *Cryptonaitca huanghaiensis* Zhang, 2008, *Cryptonaitca hirasei* (Pilsbry, 1905) and some other species have been found currently in the northern Huanghai Sea. Until now, these species only were found in Huanghai Sea Cold Water Mass, and have not been reported in other sea waters of China. Moreover, during the marine biological surveys in the Huanghai Sea in the past years, different species of *Cryptonaitca* were collected in the same station, including the three new species described in this paper. These facts illustrated that their geographical distribution and habitat environment are similar or the same.

During the investigations of benthic community structure and characteristic diversity of the Huanghai Sea Cold Water Mass conducted in June 2007 and July 2008, respectively, as well as that of the national oceanic survey, several dozens of Naticidae specimens were collected. Based on their external morphological characteristics and the internal anatomy on radula, and a comparative study on similar species. Related publications on Naticidae were referred (Kabat, 1990; Majma, 1989: Golikov and Sirenko, 1988; Kuroda, 1961; Reeve, 1855). Three new species belonging

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to genus *Cryptonatica* are identified, i.e., 1. *Cryptonatica purpurfunda* sp. nov., 2. *Cryptonatica sphaera* sp. nov. and 3. *Cryptonatica striatica* sp. nov., following the report of *Cryptonaitca huanghaiensis* Zhang, 2008.

The findings of the three new species of Naticidae in the Huanghai Sea, not only enrich the marine mollusks biodiversity research, but also provide the scientific evidence for the study of marine benthic community structure, composition and marine ecology, and provide basic material for conservation and utilization of mollusks resources.

2 Materials, methods and description

Genus *Cryptonatica* Dall, 1892

Cryptonatica Dall, 1892, Trans Wagner Inst Sci, 3:362.

Type species: *Natica clausa* Broderip and Sowerby, 1829

2.1 *Cryptonatica purpurfunda sp. nov. (Fig. 1)*

Natica clausiformis Oyama: Ma and Zhang, 1994, 4: 11, pl. 3, fig. 3 (not *Natica clausiformis* Oyama, 1969).

Material examined: Holotype, cellected from the northern Huanghai Sea, the Dalian Cai-Shen reef, depth 60 m, in muddy-sand bottom.

Thirty paratypes, cellected from the northern Huanghai Sea (37°30′–39°N, 121°40′–124°E), found in fine sandy, mud-sandy and mud bottom of 35–76 m depth.

Holotype. Shell length 24.0 mm, breadth 22.0

Paratype. Shell length 23.5 mm, breadth 20.0

Holotype and paratypes specimens are deposited in the Marine Biological Museum, Chinese Academy of Sciences (Qingdao).

Description. Shell moderate in size, growth-line dense, nearly globe or globe-ovate in shape, solid, with 4-5 whorls, suture shallow and clear. Spire low and small, body whorl large and round. Shell surface smooth, covered with thin yellow-brown periostracum. If the periostracum fall off, shell yellowish-brown or yellowish-white in color, with brown reticulations or regular brown blotches. On the body whorl with a clear dark-brown band. Growth lines thin, under the suture with radial ridges. Aperture large, semicircular, inner aperture white or light brown in color. Outer lip semicircular; inner lip nearly straight, parietal callus thick, columellar callus nearly round, umbilicus completely covered by the columellar callus, and adult body purple-brown in color, young body white in color. Operculum calcareous, thin, surface smooth, middle concave, with one fine marginal groove. Nucleus located at the inner lower part.

Habit. Cold-temperate water specie, found in fine sandy, mud-sandy and mud bottom of 35–76 m depth in the northern Huanghai Sea.

Distribution: Collected only from the Huanghai Sea.

Remarks: Ma and Zhang (1994) once named this species *Natica (C.) clausiformis*. While Oyama (1969)'s description on *Natica (C.) clausiformis* was that the shell with brown patch or spot, the body whorl without color-bands, the morphology and characteristics of umbilical region were also different from the new species. During the investigations of Huanghai Sea Cold Water Mass in 2007 and 2008, 12 Naticidae specimens were collected, and some specimens were also collected in the national oceanic survey, of which most were young, the heights of the shell were between 13–18 mm. In recent years, some adult specimens were collected, shell heights were more than 20 mm and the surface were carved with clear pattern. The columellar callus and the inner lips of most of the adult specimens are purple in color.

The shell shape of the new species is similar to that of *Cryptonatica figurata* (Sowerby, 1914), but the difference is that the new species with a purple-brown band on the body whorl, and the axis of the shell and umbilical region of the adult are also purple-brown in color. Sowerby (1914) described the shell surface of *Cryptonatica figurata* with reticulate sculpture and without purple-brown band.

Through the internal anatomy on radula, we found the central-tooth of new species with three cusps. The middle-cusp sharp-pointed and well-developed, two side-cusps are small (Fig. 1e). The lateral tooth claw-like in shape, margin with tooth-like carve. The marginal teeth are falciform, strong, inner marginal tooth not cleaved at the end.

2.2 *Cryptonatica sphaera sp. nov. (Figs 2–4)*

Material examined: Holotype, cellected from the Huanghai Sea (37°30′N, 121°40′E), depth 72.4 m, in sandy and mud bottom.

Five paratypes, cellected from the Huanghai Sea (34°59′–38°N, 122°40′–124°E), found in sandy and mud bottom of 56-81 m depth.

Holotype. Shell length 13.0 mm, breadth 12.0

Fig.1. *Cryptonatica purpurfunda* sp. nov. a. Holotype, b. paratype, c. young shell, d. operculum and e. radula.

Paratype. Shell length 12.0 mm, breadth 11.0

Holotype and paratypes specimens are deposited in the Marine Biological Museum, Chinese Academy of Sciences (Qingdao).

Description: Shell small, globe in shape, with 4 whorls, suture concave. Spire low and small. Apex white in color, body whorl large and round. Shoulder flat. Shell surface smooth, yellowish-brown in color, with big red-brown or dark-brown blotches and wavy band. The lower part of body whorl with a light-brown band. Growth lines thin. Aperture large, semicircular, inner aperture white or light brown in color, outer lip semicircular; inner lip nearly straight, parietal callus thick, columellar callus white in color. Umbilicus completely covered by the columellar callus of a nearly semicircular shape. Operculum calcareous, with 2 fine ribs and a wide marginal groove. Nucleus protrude, gray-white, located at the inner lower part.

Habit. Found in sandy and mud bottom of 56–81 m depth.

Distribution: Collected only from the Huanghai Sea. Currently only known distributed in the Huanghai Sea

Remarks: The shape of new species is similar to the young shell of *Cryptonatica andoi* (Nomura, 1935), however, the new species' suture concave, with big red-brown or dark-brown blotches and wavy band on the body whorl, umbilicus completely filled up by columellar callus, the upper part of outer margin of operculum

Fig.2. *Cryptonatica sphaera* sp. nov.

Fig.3. Morphological comparison of opercula. a. Operculum of *Cryptonatica sphaera* and b. operculum of *Cryptonaitca andoi*.

with two thread-like ribs, between the two thin ribs with a wide concave groove (Fig. 3a). While the body whorl of *Cryptonatica andoi* (Nomura, 1935) with unclear brown bands, umbilicus partly filled up by columellar callus, often with gaps. There are two concave grooves and a wide rib on operculum (Fig. 3b).

A comparitive study on the internal anatomy on radula of new species *Cryptonatica sphaera* sp. nov. and *Cryptonatica andoi* was conducted, and big difference between the two species was found. The central tooth of new species with three sharp cusps, middle cusp long-triangle in shape, while the middle cusp of *Cryptonatica andoi* short and wide, side cusps small and blunt (Figs 4a and b).

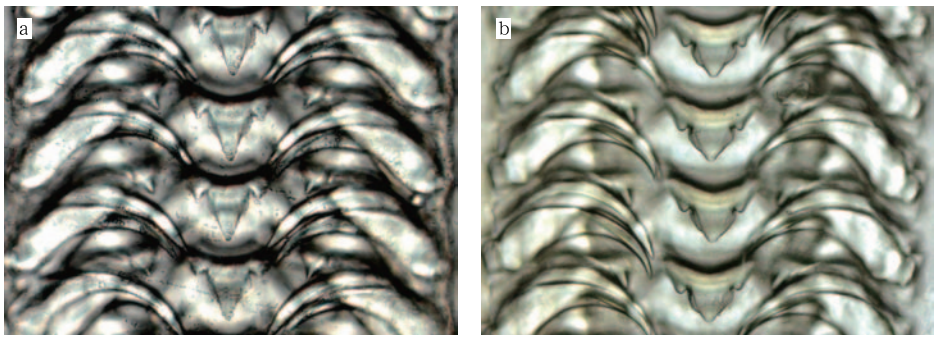

Fig.4. Morphological comparison of radulae. a. Radula of *Cryptonatica sphaera* and b. radula of *Cryptonaitca andoi.*

2.3 *Cryptonatica striatica sp. nov.(Figs 5–7)*

Natica sp. Qi et al., 1989: 53, pl. 4, fig. 10.

Material examined: Holotype, collected from the northern Huanghai Sea, near Long wang-tang, Dalian, depth 40 m, in sandy, muddy and gravel bottom.

Forty-one paratypes, collected from the Huanghai Sea (34°–39°N), found in mud, mud-sandy and gravel bottom, 37–78 m depth.

A total of 42 specimens collected, of which 8 were adult specimens.

Holotype. Shell length 24.5 mm, breadth 24.0

Paratype. Shell length 20.5 mm, breadth 20.3

Holotype and paratypes specimens are deposited in the Marine Biological Museum, Chinese Academy of Sciences (Qingdao).

Description: Shell round and thin, length nearly the same to the breadth, margin of aperture easy to be damaged. With 4–5 whorls, suture shallow and clear, body whorl low. The top 2–3 whorls dark-brown in color. Body whorl large and round. Shell surface smooth, growth lines thin and dense. Shell surface yellow-white or light-brown in color, the base is white. The central part of body whorl with a "Z"-shape purple-brown stripe composed band. Between the bands and on the both ends with longitudinal brown pinstripe. Generally, sculpture pattern varies with different individual. Aperture semicircular, inner aperture yellow-brown in color. Outer lip semicircular, inner lip nearly straight. On the middle part of the parietal callus with a small concave, which is one of the major characteristics of the species. Columellar callus thick, round and smooth, white in color, fill up the whole umbilicus. Operculum calcareous, thin, central concave, with one rib and one groove, Nucleus protrude, dark-brown in color.

Habit: Cold-temperate species, living at sandy bottom in shallow waters. We found the specimens on mud-sandy, muddy, and rubble bottom in the depth of 37–78 m. The habits of new species are similar to those of *Cryptonatica sphaera* and *Cryptonatica purpurfunda.* During the investigation of Huanghai Sea Cold Water Mass and other surveys, this species and other two new species reported in this paper were collected in the same station.

Distribut1ion: Collected only from the Huanghai Sea Cold Water Mass.

Remarks: The new species is similar in shape to *Cryptonaticai ranzii* (Kuroda, 1961), but defers from the later in the following aspects: The body whorl of new species low, the central part of body whorl with a "Z"-shape purple-brown stripe composed band, between the bands and on the both ends with longitudinal irregular brown pinstripe. While the body whorl of *Cryptonaticai ranzii* high, the body whorl and subbody whorl of adult with a row of continuous jagged purple pattern. In addition, the umbilical region and columellar callus are also different from each other,

Fig.5. Morphology of *Cryptonatica striatica* sp. nov.

the columellar callus of new species nearly round, fill up the whole umbilicus, between the columellar callus and parietal callus with a concave. Kuroda (1961) described the holotape of *Cryptonaticai ranzii* and showed that the columellar callus cannot fill up the whole umbilicus, often with a small gap. The operculum of new species with one rib and one marginal groove, nucleus dark-brown in color. While the operculum of *Cryptonaticai ranzii* smooth, without marginal groove.

Anatomical study on the radula of new species shows that the shape of the radula are very special, the central tooth well developed, middle cusp long and pointed, and without side-cusps (Fig. 7a), which is significantly different from that of *Cryptonatica purpurfunda* (Fig. 7b).

Fig.6. Operculum of *Cryptonatica striatica* sp. nov.

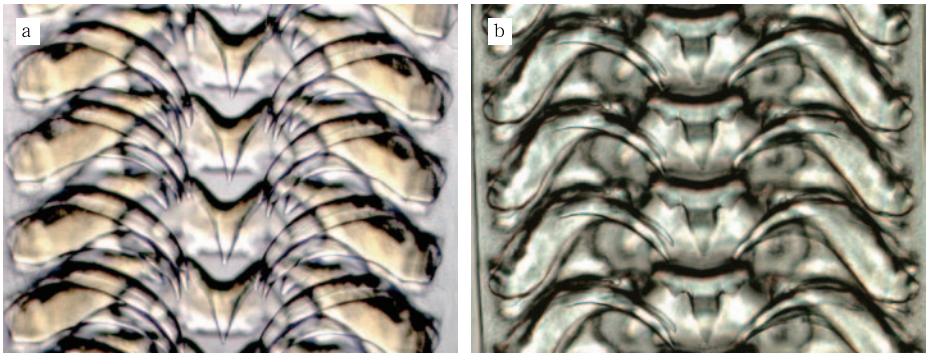

Fig.7. Morphological comparison of radulae. a. Radula of *Cryptonatica striatica* and b. radula of *Cryptonatica purpurfunda*.

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